



Environmental Agents of Mathematics: Mathematicians for Change

Curriculum Unit 10.04.06

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Introduction

The following unit focuses on the creation and understanding of data collection and scatter plots. Many textbooks concentrate on plotting points and developing linear regressions based on best-fit models. While this unit intends to accomplish these skills, it will also revolve around the notions of bias and influence to discuss how data can be manipulated to prompt specific reactions and alter public opinion. More specifically, this unit will focus on how data and scatter plots can affect public opinion on significant political debates such as environmental protection and energy resources.

As students review each topic, they will complete math applications and read articles on renewable energy that will guide their thinking and unite these fields. These mathematical skills will allow students to take an analytical stance to decipher statistics about the benefits of renewable energy and the drawbacks of sustained dependence on fossil fuels. Students will look at models created by others to see how these models have influenced society. Students will create a survey to poll the school on what they know about energy resources and what our time frame looks like before we run out. Students will also perform an experiment where they will show other students a series of clips and articles that provide conflicting information. The point of the experiment will be to see which bits of information the public clings to and which it finds most compelling. After collecting the data, students will create a series of scatter plots to analyze. The students will then create a public service announcement in response to the poll results, with the purpose being to provide accurate data about the realities of energy limitations.

In addition, students will compare news articles with reported scientific data in order to verify the validity of claims made by the media. In response to all the information (or misinformation) provided, students will develop a scatter plot and linear regression, which will be used as further evidence in their public service announcement that will share mathematically accurate predictions about the limited supply of fossil fuels. Each group will be responsible for producing its own scatter plot, with the ultimate goal being each group teaching the others about a specific element of the energy crisis. Possible scatter plots for this unit include the following:

- Energy reserves

- Energy prices
- Environmental/pollutant effects of various energy sources
- Energy consumption
- Public opinion on energy reserves
- Population v. Energy Usage

The goals of this unit are twofold. First, this unit will introduce the students to one of the large debates framing much of our societal concerns. Second, focusing the students on one application extensively will ultimately reinforce the ways in which mathematics is utilized outside the classroom.

Topics from this unit will resurface later in the year, as this unit will serve to scaffold other mathematical concepts such as systems of equations and inequalities.

This unit has been designed for implementation at Cross CT Scholars Academy (Scholars), a satellite school of Wilbur Cross High School (Cross) that works specifically with ninth and tenth grade students. Our goal is to take middle performing students and have them complete three years of math and science classes during their two years at Scholars so they can be placed in honors courses during their junior and senior years of Scholars. Most freshmen at Scholars begin their studies with Algebra 1. This unit is intended for students taking honors-level algebra. The lessons are designed to fit a 90 minute block, but can easily be adapted to fit shorter class periods. This unit should take about seven to eight block days to complete.

Because Scholars does not track its students, honors algebra work is completed as an extension to the normal work completed in class. Students not only complete differentiated work within class, but they meet after school once a week for one hour to receive additional instruction. The included lesson plans provide the framework for my normal classes along with an extension section (the last lesson or capstone project) for the honors students. Elements from this unit may be used and adapted to work for a variety of algebra levels.

Rationale Behind the Unit

Despite the widespread use of mathematics in science, technology, engineering, etc., the study of math has somehow adopted a stigma of obsolescence among many students. The question "When will I ever use this in real life?" pervades the classroom and haunts many a math teacher as they search for a meaningful way in which to demonstrate the usefulness of math outside of the standard word problem application. Perhaps the biggest detractor for students in seeing the immediate applications of math is that we, as educators, differentiate the subject areas so greatly. We study math, science, language, and social studies as separate entities, without reinforcing the connectedness of all the subject areas. Math is the study of numbers. Science is the study of life. English is the study of words. Social studies is the study of human interactions. What we as teachers often fail to reinforce is that we cannot study these topics thoroughly without overlapping into the other content areas. Life and work are rarely so clearly defined as just math or just English. Consequently, the best way to inspire our students to study these subjects is to use an integrated approach.

This unit is designed to integrate the study of scatter plots with the study of environmental science and public reaction. Students will not only learn how to collect data and create and analyze scatter plots, but they will

also have the opportunity to see how scatter plots are used in other fields to inform others. In particular, students will look at how data can create bias.

One of the most relevant areas in today's society in which scatter plots can be utilized is in the ever-growing debate on energy. One of the first major studies to analyze the future prospects of energy resources, *The Limits to Growth*, was published in 1972. The authors of the book used mathematical models based on population, pollution, industrialization, food production, and resource depletion to make predictions about a supposed social collapse in the mid 21st century. Several updates (both 20 year and 30 year updates) of the book have been published by a few different groups, all of which verify that, following our current trends, we are still on track for social destruction in our near future.

Regardless of the validity of the predictions made in *The Limits to Growth*, one thing is clear: the mathematical models created and used by the authors spawned serious public debate and opened the floodgates for an era of change. Through hybrid cars, solar panels, windmills, and hydroelectric generators, the world is desperately trying to stave off an energy crisis. And if mathematical models have the power to push forward an energy revolution in real life, why not in the classroom?

Unit Objectives

This unit aligns with the third unit of the New Haven Public Schools Algebra 1 curriculum, which focuses on graphing. Students should already be familiar with graphing points on the Cartesian plane, though this unit provides a review. The unit begins with an introduction to collecting and organizing data into tables and concludes with the creation of scatter plots and linear regressions using a best-fit model. In addition to introducing new vocabulary on graphing, this topic will reinforce the prior unit of study on evaluating expressions while also establishing an initial foundation for the next unit on solving equations.

Students will begin by studying scatter plots. They will learn how to identify independent and dependent variables, how to properly create and label scatter plots, how to determine the correlation between data sets, how to find the line of best fit, and how to make predictions based on this line. Most importantly, students will learn to reflect on the validity of data and the potential misconceptions that can arise.

Although the creation of scatter plots and linear regressions are the primary foci of this unit, students will also discuss the idea of bias and the validity or significance of a set of data. By the end of the unit, students should be able to differentiate between correlation and causation.

Through the presentation of the mathematical ideas in this unit, students will be introduced to the energy crisis debate. Students should be able to argue for either side of the debate and support their claims using data and mathematical evidence.

Finally, students will demonstrate their understanding of the information presented in this unit by filming a public service announcement. The service announcement is meant to frame the students' understanding of each objective while influencing the public about the harsh realities of the energy crisis.

Overview and Background Information

Bias and Collecting Data

The initial component of analyzing data is determining what information you would like to gather. When deciding on the type of data to collect, you should consider several factors. Among the many factors one must consider is whether the two variables are actually related. While scatter plots can be used to test relatedness, they are actually more useful as indicators of how two variables are related.

The way in which you plan to collect data must also be considered. Where will the data come from? Experimentation? Survey? Who or what should be included in the collection process? How should the data be measured?

Ironing out how you choose to sample data is perhaps the most crucial element of collecting data if you want to create unbiased results. If you look at the correlation between pollution levels in cities and population happiness, you wouldn't want to include people who don't live in the city in your sample. You also want to standardize answers. How can you measure a person's level of happiness? You should also consider the manner in which you choose to word questions if collecting information via a survey. It is important to create non-suggestive questions; that is, create questions that don't hint at a specific answer. Designing an experiment or survey in an attempt to obtain specific results will most likely do just that. Unfortunately, these data may not reflect the actual relationship between two variables.

Creating Scatter Plots

Scatter plots are simple graphs that represent a relationship between two variables. The independent variable is graphed on the x-axis, while the dependent variable is graphed on the y-axis. A proper scatter plot should include a title, labeled axes, and appropriate scaling. The title should be short, but descriptive. Once the scatter plot is set up, use the x- and y-coordinates of the ordered pairs to plot points.

Plotting points follows a simple procedure. The first coordinate of an ordered pair represents the x-coordinate and indicates how far to move from the origin along the x-axis. The second coordinate in the ordered pair represents the y-coordinate and indicates how far to move from the origin along the y-axis. If we were to sketch a vertical line from the x-axis and a horizontal line from the y-axis, we would plot a single point where these two lines intersect. Scatter plots are comprised of several points. In general, the more points, the more representative the data.

Interpreting Correlation and Bias

Correlation refers to the interdependence of two variables and is perhaps one of the most common initial forms of data analysis. After any set of data has been collected and organized, an analyst almost immediately checks to see if a correlation exists between the variables. The type of correlation depends on how the data (points) are scattered (or clustered). There are five types of correlation: strong positive, strong negative, weak positive, weak negative, and no correlation.

A strong correlation indicates that the data are tightly clustered and follow a specific trend or pattern. A weak correlation indicates that the data are scattered with only a slight visible pattern. Conversely, no correlation is indicated by a clear lack of pattern in the data. As stated earlier, correlation indicates whether a relationship

exists between two variables. Correlation does not, however, indicate causation.

When interpreting the correlation of a set of data, it is important to consider several factors, such as whether the variables have extraneous connections not considered during the data collection process or whether the data were collected using a method that could potentially alter or affect the results in a specific manner.

Renewable and Nonrenewable Resources

Energy is one of the most frequently discussed and debated topics in the media today. With an ever growing population and a dwindling supply of fossil fuels, the public has begun looking toward more sustainable forms of energy.

Resources can be classified as either renewable or nonrenewable. Renewable resources are those that can be replenished naturally if once alive or biochemically if nonliving. Examples of renewables include resources like trees, which can be replanted or regrown if cut down or if it dies. Nonrenewable resources are those sources that cannot be replenished via natural processes, such as most of our primary energy sources like coal, natural gas, and oil. ¹ These energy sources took millions of years to be converted from organic matter to fossil fuels. The move toward more sustainable resources has stemmed from a decrease in fossil fuel reserves, an increase in environmental awareness (a socio-political obligation to future generations), and increasing prices of resources such as petroleum.

Background Information on Carbon and the Greenhouse Effect

Carbon is the building block of organic life. It also serves as an energy source. Energy is found in many forms and transferred in a variety of ways through the carbon cycle. In fact, carbon is transferred using four processes: biological, geochemical, mixed biogeochemical processes, and human activities. ²

Vegetation absorbs carbon from the atmosphere, which can then be used as biofuels. In addition, plants use carbon dioxide to fuel photosynthesis to create carbohydrates, which are then consumed by humans and other animals. These carbohydrates are transferred throughout the food chain as a source of energy. Animals then release carbon in a variety of manners. Besides respiration, carbon that breaks down from dead plants and animals enters the soil and after millions of years and lots of pressure becomes a source of fossil fuels. ²

Geochemical processes include volcanic activity and erosion that release carbon either into the atmosphere or introduce it into the ocean. Human activities like burning fossil fuels (power plants, automobiles, etc.) and forests releases carbon back into the atmosphere in the form of carbon dioxide. ¹

The greenhouse effect is one of the most well known environmental issues today. Normally, a percentage of light and heat from the sun enters the atmosphere while another percentage is reflected back into space. ³ The greenhouse effect essentially results in a higher percentage of heat being captured in Earth's atmosphere by greenhouse gases such as carbon dioxide, water vapor, methane, and nitrous oxide. This capture then results in warmer average temperatures, which impacts precipitation patterns, storm severity, and sea levels.

³

It is particularly important for Americans to understand the greenhouse effect, as carbon dioxide is a byproduct of fossil fuels and since about 98% of American carbon emissions stem from fossil fuel usage. In fact, about 85% of American energy comes from fossil fuels. In 2004, the United States was responsible for almost 22% of worldwide carbon emissions. ³ As the largest economy in the world, Americans have a

responsibility for the earth. With the help of the current administration, scientific advancements and environmentalists, the U.S. is expected to lower its carbon impact by 36% by 2030. Of course, this will greatly depend on continued support by the American public. ³

Background Information on Energy Reserves

Fossil fuels are a type of nonrenewable energy. While deposits were created naturally, they took millions of years under high pressure to be converted from organic matter to something usable as energy. Once our fossil fuel reserves have been used up, we will no longer be able to rely on fossil fuels as a primary resource. Thus, monitoring our fossil fuel reserves is crucial (fossil fuel reserves refers to the remaining amount of a particular type of fossil fuel that can be mined given current deposits ⁴). Refer to the appendix to see a table of coal reserves. This information can be used in Lesson 4 for the public service announcement project.

A Change in Public Opinion on Climate Change

The driving force behind any kind of social change is the extent to which the public perceives a need for change. Several polling agencies (Gallup and Pew Research) poll the public on a regular basis to gauge the public opinion on several matters. Climate change is one such topic and the newest results are concerning. "Belief that global warming is occurring had declined from 71 percent in April of 2008 to 56 percent in October -- an astonishing drop in just 18 months. The belief that global warming is human-caused declined from 47 percent to 36 percent." ⁵

Public Service Announcements

Public service announcements are a type of advertisement meant to raise awareness about an issue, impact public opinion about said issue, and possibly prompt social action. PSAs can be a powerful tool in manipulating public opinion, and are often used to reiterate the importance of creating social change when public focus wanes. ⁶

Concept List

By the end of this unit, students should be able to explain or define each of the following terms or ideas.

1. Line of Best Fit
2. Extrapolate
3. x-Coordinate
4. y-Coordinate
5. Interpolate
6. Ordered Pair

7. Scatter Plot
8. Correlation
9. Bias
10. Coordinate Plane
11. Outlier

Lesson 1: Organizing Data into Tables and Graphs (1 day)

Prerequisite Knowledge and Objectives

Before beginning this lesson, students should already know how to evaluate expressions and find subsequent values in a recursive pattern.

By the end of this lesson, students will be able to organize real world data into tables and then graph the resulting ordered pairs. Students will initially demonstrate their understanding by completing two activities in this lesson and in later lessons by creating scatter plots from data that have either been given to them or from data they've collected.

Opening

For the opening, have the students complete a K-W-L chart for domain and range. The activity should be completed as a class.

Pre-Knowledge: What you already KNOW

Have you ever heard the words domain and range? What do these words mean to you? Where have you heard them?

Students may have heard these words in different contexts. It is often helpful when learning new vocabulary if students associate them with words or concepts they already know. Students may have heard the word domain used to talk about territory in history class or range used to discuss distance or a span of space. Students might also associate range as a measure of central tendency, as in when they studied mean, median, mode, and range in middle school.

Mini-Reading and Discussion: What you WANT to know

Have the students read this short blurb on domain and range. Then, proceed into a discussion on the terms.

The domain of an expression is all of the possible values for which x can be. For example, in the expression $2x$, x can be any value positive, zero, or negative because no mathematical restrictions are placed on x . The domain of an expression is often all real numbers, unless a given mathematical operation becomes undoable using certain numbers. Look at the expression $2/x$. The operation in this expression is division. We know that we can divide by any number other than zero, so the domain can be any real number besides 0.

The range of an expression is the values for which the evaluated expression can be. For instance, the expression $2x$ can be any positive number (as long as x is positive), any negative number (as long as x is negative), or zero (as long as x is 0). Like domain, the range of an expression is sometimes restricted. Look at \sqrt{x} . No value of x can ever make this expression negative. Thus, the range of \sqrt{x} is zero and all positive numbers.

In mathematics, the definitions we came up with at the beginning of class are not wholly different than the ones we just read. The domain of an expression is indeed the territory or the space in which the x -values reside, while the range is the span of values for which the expression can be.

Practice: What you LEARNED

Put the following expressions on the board: x^2 and $x/4$. Feel free to use other expressions, but remember that algebra 1 students have a limited knowledge of any functions that go beyond the five basic mathematical operations: exponents, multiplication, division, addition and subtraction. By the end of the year, students should also be to apply this to absolute value functions. Underneath each expression, write "domain:" and "range:". Give the students an opportunity to come to the board and determine what the domains and ranges are for each expression. After students have had a chance, review and discuss the solutions.

Activity 1: Building Tables

Provide the students with the following information. Then, ask them to complete the table one row at a time. Students should be able to hypothesize when coal reserves will run out.

The Energy Information Agency (EIA) reports that, in 2007, the total U.S. recoverable (mineable) coal reserves were 18,584 million short tons. ⁷ Recoverable coal reserves refer to the amount of coal that can be mined from existing coal reserves. In 2008, the recoverable reserves in the U.S. fell to 17,875 million short tons. At what rate are the reserves being depleted each year? If we assume that the U.S. will continue to use coal at the same rate for the next 25 years, how many million short tons will remain by the end of this period? Students will use the data to determine whether or not the U.S. can continue to depend on domestic coal reserves at our current consumption level.

To complete this activity, have the students complete the activity handout (Lesson 1 Activity 1) found in the appendix. Initially, the students will be asked to simply subtract 709 million short tons (the difference of 18,584 and 17,875) for each year. After the first 5 years, however, the students will be asked to develop a rule that they can follow so they don't have to subtract one year at a time. This will be a short introduction to writing equations of a line, though it will not be introduced in those terms until Unit 5, following the district curriculum. By the end of this activity, students should have a completed table and a rule that states the reserve level x years after 2007 is $18,584 - 709x$. The students already know how to evaluate an expression, so they should feel comfortable applying this rule.

Discussion and Short Lecture

After completing the above activity, transition into a discussion on coal and its connection with the carbon cycle. In the next activity, students will gain a better understanding of the carbon cycle along with learning to graph points. If you have time, you may also have your students read the following short articles on coal consumption; the third is actually a short clip from YouTube.com:

"US Coal Consumption Trends":

<http://www.examiner.com/x-325-Global-Warming-Examiner~y2010m5d8-US-coal-consumption-trends> (July 30, 2010) discusses expected American consumption rates and provides a brief discussion on the need to decrease our coal dependence for environmental reasons.

"Oil Is Not the Climate Change Culprit It's All About Coal":

<http://www.wired.com/wiredscience/2008/12/oil-not-the-cl/> (July 30, 2010) discusses the negative impact of continued coal consumption.

"A Convenient Truth": <http://www.youtube.com/watch?v=71kckb8hhOQ> (May 31, 2010) a comical satire of a public service announcement in favor of coal consumption.

Before beginning the next activity, review with the students how to plot a point. Be sure to go over which axis is the x-axis and which is the y-axis.

Activity 2: Graphing Points and the Carbon Cycle

This activity is based on the two-person game Battleship, but has been modified to fit into a unit on energy. Students will each be given a board with the carbon cycle on it. A copy of the game play board can be found in the appendix. All freshmen students study the carbon cycle at Scholars in their Physical Chemistry class, so the transference of carbon in the cycle is understood at least on a basic level. In this game, students will be given 6 carbon molecules to place anywhere in the atmosphere. Their opponent will call out ordered pairs in an attempt to capture the free carbon in the atmosphere. If a player correctly guesses the coordinates of a carbon molecule, the carbon will move to another section of the carbon cycle. The first player to move 3 carbon molecules from the atmosphere to water, water to biomass (plants and animals), from biomass to fossil fuels, and then from fossil fuels back to the atmosphere wins. If a group finishes early, encourage them to play again.

The objective of this activity is not only to have the students practice plotting and reading points in the coordinate plane, but to also familiarize the students with the carbon cycle and reiterate some of the points about how coal consumption can impact the environment.

Discussion

After students have completed the game, have a quick discussion with the students about how carbon flows through the carbon cycle. Have a large playing board at the front of the class and ask students to identify where the carbon molecules are by naming the ordered pairs. Then, have the students explain where the carbon can potentially move within the cycle.

Exit Ticket

As the closing, have the students write down three things they learned about carbon in today's lesson.

Lesson 2: Correlation and Bias (2 days)

Prerequisite Knowledge and Objectives

Before beginning this lesson, students should already know how to plot a point and create a scatter plot. Students will demonstrate their understanding by completing the warm-up.

By the end of this lesson, students should be able to determine the type of correlation that exists between two variables and the significance of that correlation. Students will demonstrate a basic understanding by completing the exit ticket, homework, and ultimately their capstone project.

Deforestation Video

Download and play the video A Convenient Truth from the FAO*. The amount of video shown should depend on the students' familiarity with the carbon cycle. If students have a limited understanding, you may choose to show more of the video. Whereas, if students have already studied the carbon cycle in science or gleaned enough information from the activity in lesson one, then you may only need to play the beginning segment on how trees absorb carbon from the atmosphere. This segment will serve as an introduction to the next activity.

*Created and posted by the Food and Agricultural Organization (FAO) of the United Nations (to download, go to the web address <http://www.fao.org/forestry/52980/en/>)

Deforestation Activity

As you heard and saw in the video, the greenhouse gas carbon dioxide is absorbed by trees. One of the increasingly problematic issues is that deforestation reduces the number of trees. Logically, it stands to reason that with fewer trees, we'll absorb fewer greenhouse gases and the temperature of the atmosphere will rise. However, how can we show this relationship? Through experimentation, of course. In the next activity, we'll run a simple experiment, collect and graph the data, and look for patterns.

Students will divide into four teams. Each team should be comprised of a different number of students; e.g. 2, 4, 6, 8. Each team will start on one end of the room and must run to the opposite end to collect as many balloons as they can in one minute. When students return to the original side of the room, they must drop their balloons in their team's basket. At the end of the minute, have a student record the number of balloons each team collected on the board. Students will organize the data into a table and then create a scatter plot. For even better results, repeat the experiment to increase the number of data points you have to plot. Use this activity as a lead-in for a discussion on correlation.

The game can be modified so that larger groups can play. Instead of having everyone play at once, students can play multiple rounds and record the data after each round. This could allow for data collection with up to 20-25 students all at once. Also, if technology is available and students are already proficient with graphing by hand, a student could enter the data directly into a graphing calculator and then create a scatter plot in that manner. This could serve as the perfect opportunity to teach technology and to discuss window settings. While using technology prevents students from practicing plotting points, it could save time, especially if the students don't need to practice plotting points. Students should still practice labeling the scatter plot appropriately and defining the variables.

Discussion on Correlation and the Relationship Between Deforestation and Global Warming

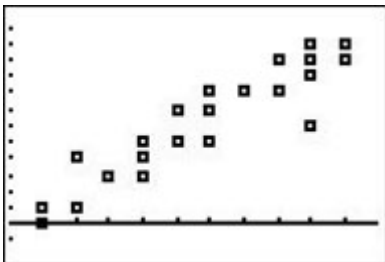
Point out that experimental/survey data are rarely (if not ever) perfect and that differences in skill or behavior can impact results. This idea can also be seen when plants of the same species undergo photosynthesis at different rates. This could be a result of the soil in which the plants live or the amount of exposure the plant has to light each day. This may also explain why the data are scattered and not lined up perfectly as we saw in our previous lesson (Lesson 1 Activity 1) when we were given a specific pattern to follow. Scatter plots do not provide a definitive relationship between two variables, but allow us to analyze patterns that emerge.

Turn to the student-produced scatter plot on the board. Ask the students to describe the data. What's going on in the graph? Are there any patterns? What happens to the number of balloons collected as the group size gets larger? This should be an example of a positive correlation. As the independent variable increases, so does the dependent variable. Refer to Figure 1 for an example of a positive correlation.

Significance of the game: each player represents a tree and the balloons the players collect symbolize greenhouse gases absorbed from the atmosphere. Regardless of athleticism, teams with more players should be able to collect more balloons. As the number of trees decreases, what happens to the amount of greenhouse gases that are absorbed? Correlation allows us to name patterns that exist in data, which helps us identify the type of relationship that exists.

Lastly, discuss the other types of correlation that exist: positive, negative, strong, weak, or none. Of course, we want to be as specific as possible when discussing correlation, so we can have strong or weak positive correlations or strong or weak negative correlations.

Figure 1



Practice Identifying Types of Correlation

Have the students practice identifying the type of correlation that exists by providing the students with a number of scenarios. For example, what kind of relationship do students think exists between the number of greenhouse gases in the atmosphere and the number of people diagnosed with asthma each year? Diagnosed with malaria? How about the number of cars purchased around the world each year and the amount of oil reserves remaining? Ask the students to create a hypothesis and then explain their reasoning.

After the discussion, distribute the following short articles for the students to read:

"Climate Change Linked to Rise in Malaria, Asthma":

http://www.usatoday.com/weather/climate/2005-11-02-climatechange-disease_x.htm (June 3, 2010) discusses the effects of greenhouse gases and climate change on the spread of diseases like malaria and asthma.

"Falling Oil Reserves Put World at Risk":

<http://energy-conservation.suite101.com/article.cfm/society-set-to-run-on-empty-as-oil-runs-out> (June 15, 2010) discusses the possibility of running out of oil and briefly mentions how car productions impact oil reserves.

Closing: Boobquake (Audio Clip: Wait, Wait, Don't Tell Me; show date 5/1/10; clip time within show 8:15-11:15; can be downloaded free of charge from iTunes)

Overview of Audio Clip:

- Iranian cleric claimed that earthquakes were God's punishment for scantily clad women.
- Indiana woman refutes claim of the existence of boobquakes. Organizes a day of nakedness, which was followed by a 6.9 earthquake on the Richter scale.

Background Information

About 500,000 earthquakes occur each year, 100,000 of which can actually be felt. The majority of large earthquakes take place in the Pacific Ring of Fire, a horseshoe shaped zone that follows the Pacific coasts of the Americas, Asia, and Australia.

Natural earthquakes are caused when tectonic plates slide against or on top of one another. The intensity of an earthquake is measured on the Richter magnitude scale. Any earthquake measured above a 6.0 is considered strong, as clear vibrations can be felt above ground. Approximately 120 6.0-6.9 level earthquakes occur each year.

- Information was taken from Wikipedia.org (<http://en.wikipedia.org/wiki/Earthquakes>)⁸

Discussion/Cliff Hanger

We know that earthquakes occur all the time at a variety of magnitudes, and that natural earthquakes result from shifts in tectonic plates. Yet here was an experiment that attempted to disprove a correlation, but really gave further evidence of the cleric's hypothesis.

If correlation does not indicate causation, why do we care about it? What does correlation tell us?

Homework

Add the eleven definitions (listed earlier in the unit under "Vocabulary") I provided to your vocabulary flashcards. Remember to define the words using your own version of the definition.

Lesson 3: Linear Regressions using Best-Fit Models (2 days)

Prerequisite Knowledge and Objectives

At this point, students should know how to plot points, how to create a scatter plot, and how to identify the type of correlation that exists between two variables.

Students will be able to draw a line of best fit given a scatter plot. Students will revisit this idea after they have learned to write the equation of a line. For now, they will use the line to make predictions about future outcomes.

Main Activity: Human Graphing

Students will learn to fit data with a linear regression and to then use said regression to either interpolate or extrapolate data.

Before class begins, create a giant coordinate plane on the floor using tape. If you have the resources, you can use different colored tapes for the axes and for the grid. You will also need at least two different colored strands of yarn.

Next, have students stand on the graph at specific points. Two students will create a line of best fit using a piece of yarn and standing at the edges of the graph. The goal is to make sure that about half the points are above the line and half are below. The line may go through some of the points (i.e. the yarn may touch several people), but you should point out to the students that most of the points do not lie on the line. The line of best fit essentially illustrates the pattern created by a set of points. Have the students create different scenarios where they shift around on the graph.

In each scenario, have the students interpolate values for the independent and dependent variables, given the opposite. For example, if $x = 2$, use the line of best fit to interpolate the value of y . Because the students have not learned to write the equation of a line, the full benefits of extrapolating data from a line of best fit cannot be reached just yet. For this lesson, explain the idea of extrapolation and indicate how looking at the line of best fit can help you determine other points.

We can also use this activity to discuss the notion of outliers. What are they? Why are they interesting? What do outliers tell us about our data? What caused the outliers? Why is it important we don't throw these data points out when analyzing our data? Have a second pair of students create a second line of best fit using a different colored piece of yarn having ignored the outlier. What did that do to our line? Did the line shift? Up or down? How would this affect our interpolation/extrapolation results? Where is the line affected more: inside or outside? That is, does ignoring outliers more strongly affect the results of interpolation or extrapolation? Discuss that extrapolating values from the line takes place much further down the line, so while results may look significant (or insignificant) for interpolation, the extrapolated data are affected even more.

If students need more practice plotting points prior to this activity, preempt this activity by having the students practice graphing points on the coordinate plane.

Extrapolating Data: Fossil Fuel Reserves

Divide the students into pairs and provide each group with a set of data on energy reserves (links to data on crude oil, natural gas, and coal can be found below). Data and graphs can be found online at the EIA.gov website. Have the students create a scatter plot of the data, indicate the type of correlation that exists, draw a line of best fit, and extrapolate how much of their given fossil fuel will remain after a certain number of years (5, 10, 25, 50, and 100 years). Note, for some data, a graph may already be given. In this case, have the students indicate the type of correlation that exists, draw the line of best fit, and extrapolate how much of the fossil fuel will remain. Next, indicate when the energy reserve will dry up according to the linear regression. Finally, discuss the limitations of a linear regression. At some point, the dependent variable will fall below zero. What do negative numbers represent in this case? Can we have a negative energy reserve?

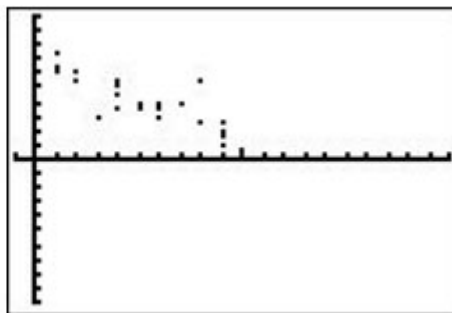
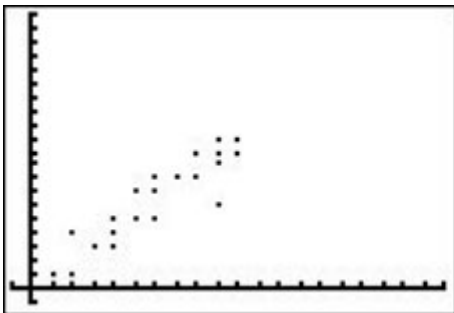
The following links provide useable data on fossil fuel reserves. All links were accessed in July 2010.

- Crude Oil Reserves: http://www.eia.gov/dnav/pet/pet_crd_pres_dcu_NUS_a.htm
- Natural Gas Reserves: http://www.eia.gov/dnav/ng/ng_enr_sum_dcu_NUS_a.htm
- Coal Reserves: <http://www.eia.doe.gov/cneaf/coal/reserves/reserves.html>

Once the students have completed the activity, have the students present their data to the rest of the class. Use the presentations as a lead-in to a discussion on the restrictions of regressions and to the limitations of fossil fuels as a long-term energy source. Why is it important that we begin researching renewable energy sources right now? Even if certain reserves won't deplete for centuries, what impacts might continued dependence have on the environment? On future generations? Return to the discussion on global warming from Lesson 2. Along with increased carbon emissions, deforestation reduces the amount of carbon absorbed from the atmosphere, thus allowing for an increase in greenhouse gases and a rise in global temperatures. We also saw an increase in certain diseases.

Closing

Distribute the following scatter plots. Have the students draw the lines of best fit and extrapolate the values of y for each graph when $x = 20$.



Lesson 4: Capstone Project (3 days)

Project Overview

This project is composed of four parts. The first component is to look at current energy reserves. Students will look at the type of correlation that exists between time and reserve levels as a means of showing why nonrenewable energy cannot be relied upon forever. Second, students will research alternatives and figure out what the benefits and drawbacks are toward switching to renewable energy sources. For the third section of this project, students will poll the school to gauge public opinion about energy. Students will ultimately create a public service announcement to inform the public of the importance of switching to more sustainable forms of energy.

Prerequisite Knowledge and Objectives

Students will create a scatter plot of energy reserves and energy consumption. They will use these data to determine lines of best fit, which will help them predict future availability of renewable and nonrenewable forms of energy. Students will then compare the data with various articles on energy reserves and discuss any discrepancies that may exist. Finally, students will meld the information gleaned from articles with the information found from analyzing scatter plots to design and tape a public service announcement.

Part 1: Picking a Topic

Choose one of the following topics (each a major type of nonrenewable fossil fuel) and research reserve levels (links to data can be found in Lesson 3). Each group will be responsible for plotting the data set and analyzing the correlation and given projections. Reserve levels can be looked up using the Energy Information Agency website.

- Coal Reserves
- Natural Gas Reserves
- Oil Reserves

Part 2: Researching Alternatives

Throughout this unit, students have read articles, discussed and learned about the negative impact that carbon emissions and fossil fuels have on our environment. And, in the last lesson, students produced scatter plots and linear regressions to hypothesize when specific fossil fuels will be completely depleted. During this section, students should research alternative renewable energies and learn about the benefits they have for the environment and sustaining our society. Students should answer the following questions about the type of renewable energy they are either assigned or pick (possible alternatives include solar energy, wind energy, and hydroelectric energy).

1. What are the benefits of this type of energy?
2. Is this energy source a realistic option considering current energy needs?

3. What are the financial and economic implications of harnessing this energy source?

Part 3: Polling the Public

Students should go into the school and poll their fellow students about energy and its impact on the world. The goal is to have the students first present short clips and articles to other students and then have them answer a short series of questions to see what information the public clings to most.

Before polling the public, students should read the article *Apocalypse Fatigue* (<http://e360.yale.edu/content/feature.msp?id=2210>). This may help the students better understand current public reactions to the type of information they're being given.

Possible articles that students can use when polling students include the following, which have been divided up into alarmist type articles, middle of the road articles, and write-off articles (articles that downplay the effects of continued fossil fuel usage).

"Rushing to Judgment" by Jack Hollander:

<http://meteo.lcd.lu/globalwarming/Hollander/RushingJudgment.pdf> (June 2010) discusses the over-reaction and hastiness of alarmist claims that global warming is unnaturally brought on by human consumption of fossil fuels.

"Hot and Cold Media Spin Cycle: A Challenge to Journalists Who Cover Global Warming" by Senator James Inhofe (speech can be downloaded for listening or viewing):

<http://epw.senate.gov/speechitem.cfm?party=rep&id=263759> (July 2010) downplays alarmist views on global warming, but does not downplay the possible existence of global warming itself. The author argues that the media needs to cover both sides of the energy debate thoroughly.

"Global Warming Heats Up" by Jeffrey Kluger:

<http://www.time.com/time/magazine/article/0,9171,1176980,00.html> (July 2010) this Time Magazine article discusses the many dangers of global warming and the rapid arrival of its effects.

An Inconvenient Truth by Al Gore a widely publicized and viewed film educating the public on the dangers of global warming.

Once data on the public opinion have been collected, students should create and analyze a scatter plot to see if a correlation exists between worsening environmental impacts and public opinion on said problem.

Part 4: Creating the Public Service Announcement

Students should take all the information they've learned in this unit and meld the most important ideas together to create and film a provocative public service announcement that warns against relying too heavily on fossil fuels and pushes for a shift toward renewable energy. Students should include at least one scatter plot in their PSA as evidence. While students are not meant to explain how they developed the scatter plot, they should use it as a tool to further their argument.

Notes

- ¹ Miller and Levine, "Renewable and Nonrenewable Resources," in Biology, 144
- ² Miller and Levine, "Cycles of Matter", in Biology, 76-77
- ³ Energy Information Agency, "Green House Gases, Climate Change and Energy," 1-4
- ⁴ Energy Information Agency, "Recoverable Reserves," in Annual Coal Report, 35-40
- ⁵ Nordhaus, Apocalypse Fatigue: Losing the Public on Climate Change, 1
- ⁶ "Public Service Announcement," from wikipedia.org
- ⁷ Energy Information Agency, "Recoverable Reserves," in Annual Coal Report, 35
- ⁸ "Earthquake," (May 2010) <http://en.wikipedia.org/wiki/Earthquakes>

Bibliography

- Miller, Kenneth and Joseph Levine, Biology, Pearson: Prentice Hall, 2006. This is the introductory biology textbook used across New Haven public schools. It serves as a basic foundational resource about renewable and nonrenewable energy, the carbon cycle and the greenhouse effect.
1. Energy Information Agency, "Green House Gases, Climate Change and Energy," 2008. This is an informational pamphlet published by the U.S. Energy Information Agency to spread information and awareness about the detriments to rising quantities of greenhouse gases in the atmosphere. The pamphlet provides information on what greenhouse gases are and how rising levels impact the environment.
 2. Energy Information Agency, Annual Coal Report, 2008. This is the 2008 annual coal report published by the U.S. Energy and Information Agency. This document contains information on coal production, recoverable coal reserves, domestic markets, mining prices and consumer prices.
 3. Nordhaus, Ted and Michael Shellenberger, Apocalypse Fatigue: Losing the Public on Climate Change. <http://e360.yale.edu/content/feature.msp?id=2210>> This article is an opinion article published in Yale's Environment 360 publication (created by doctoral students in environmental studies) by the same authors
 4. of Break Through: From the Death of Environmentalism to the Politics of Possibility. It discusses trends in public opinion on climate change and how Americans appear to be growing less concerned about environmental hardships. It also claims that to increase public attention, we must move away from alarmist warnings and focus more on providing general information.

"Public Service Announcement," http://en.wikipedia.org/wiki/Public_service_announcement>. Accessed 5. May 2010. This source provides basic information about what a public service announcement is and its purpose.

Resources

Suggested Websites

1. AmericanForests.org
2. Nature.org
3. EarthShare.org
4. e360.yale.edu
5. theBreakThrough.org
6. BionomicFuel.com
7. EIA.gov (Energy Information Agency)
8. environment.NationalGeographic.com

Suggested Student Reading

1. "Annual Energy Review" by the EIA
2. The Limits to Growth by Donella Meadows
3. "Apocalypse Fatigue" by Ted Nordhaus and Michael Shellenberger
4. Break Through: From the Death of Environmentalism to the Politics of Possibility by Ted Nordhaus and Michael Shellenberger
5. "Getting Real on Climate Change" by Ted Nordhaus
6. Algebra by Larson, Boswell, Kanold, Stiff
7. Biology by Miller Levine
8. "Long-Term World Oil Supply Scenarios: The Future Is Neither as Bleak or Rosy as Some Assert" by John Wood, Gary Long, and David Morehouse

Materials for Classroom Use

1. Video Camera (for the PSA)
2. Colored Tapes (for creating a giant graph on the floor)
3. Yarn (2 colors)
4. Balloons (for the carbon collecting game)

Appendix

Coal Reserves ⁷

Table 14. Recoverable Coal Reserves and Average Recovery Percentage at Producing Mines by State, 2008, 2007
(Million Short Tons)

Coal-Producing State	2008		2007		Percent Change Recoverable Coal Reserves
	Recoverable Coal Reserves	Average Recovery Percentage	Recoverable Coal Reserves	Average Recovery Percentage	
Alabama.....	330	57.98	327	57.15	1.0
Alaska.....	W	W	W	W	-
Arizona.....	W	W	W	W	W
Arkansas.....	W	W	W	W	-
Colorado.....	325	70.92	328	72.85	-0.9
Illinois.....	1,189	60.43	1,286	61.99	-7.5
Indiana.....	421	69.52	401	67.58	5.1
Kansas.....	W	W	W	W	W
Kentucky Total.....	1,167	58.37	1,182	59.91	-1.3
Eastern.....	729	56.12	669	54.98	8.9
Western.....	438	62.11	513	66.34	-14.6
Louisiana.....	W	W	W	W	W
Maryland.....	22	74.01	24	61.75	-9.1
Mississippi.....	W	W	W	W	W
Missouri.....	W	W	W	W	W
Montana.....	925	89.55	1,251	88.01	-26.1
New Mexico.....	605	88.44	483	90.64	25.4
North Dakota.....	1,225	90.60	1,252	90.64	-2.2
Ohio.....	308	69.32	333	73.00	-7.6
Oklahoma.....	85	54.74	155	52.67	-45.6
Pennsylvania Total.....	526	71.96	532	71.69	-1.2
Anthracite.....	24	76.48	28	62.59	-13.4
Bituminous.....	502	71.74	504	72.19	-0.5
Tennessee.....	10	75.05	12	79.31	-16.9
Texas.....	752	90.82	737	90.04	2.0
Utah.....	212	56.97	211	57.92	0.4
Virginia.....	217	55.80	256	56.25	-15.4
Washington.....	-	-	-	-	-
West Virginia Total.....	1,908	57.24	1,828	57.49	4.4
Northern.....	338	60.50	303	61.18	11.5
Southern.....	1,570	56.54	1,525	56.76	2.9
Wyoming.....	7,010	91.52	7,330	91.36	-4.4
U.S. Total.....	17,875	79.64	18,584	79.92	-3.8

- = No data are reported.

W = Data withheld to avoid disclosure.

Note: • Recoverable reserves represent the quantity of coal that can be recovered (i.e., mined) from existing coal reserves at reporting mines. Average recovery percentage represents the percentage of coal that can be recovered from coal reserves at reporting mines, weighted for all mines in the reported geographic area. Excludes mines producing less than 10,000 short tons, which are not required to provide data and refuse recovery. Totals may not equal sum of components because of independent rounding.

Source: • Energy Information Administration Form EIA-7A, "Coal Production Report," and U.S. Department of Labor, Mine Safety and Health Administration, Form 7000-2, "Quarterly Mine Employment and Coal Production Report."

Activity Worksheets and Handouts

Lesson 1 Activity 1 Handout

Name _____ Date _____ Period _____

Building a Table: American Coal Reserves

Objective

To organize recursive data in tables and then use the data to make predictions about future levels of reserves.

Background Information

The Energy Information Agency (EIA) reports that, in 2007, the total U.S. recoverable (mineable) coal reserves were 18,584 million short tons. Recoverable coal reserves refer to the amount of coal that can be mined from existing coal reserves. In 2008, the recoverable reserves in the U.S. fell to 17,875 million short tons.

Creating the Table

At what rate did the reserves deplete between 2007 and 2008?

_____ million short tons/year

Assume that the U.S. will continue to use coal at the same rate for the next 20 years. Complete the table below.

Year	Coal Reserves
2007	18,584
2008	17,875
2009	
2010	
2011	
2012	
2013	
2014	
2015	
2016	

Year	Coal Reserves
2017	
2018	
2019	
2020	
2021	
2022	
2023	
2024	
2025	
2026	

Analysis

How many million short tons remain by 2019? _____

How many million short tons remain by the end of this period (2026)? _____

Develop a rule to find the coal reserves for any given year.

Use the rule to determine the amount of reserves remaining for each year indicated.

Year	Coal Reserves
2028	
2030	
2035	
2050	

Hypothesize when you think American coal reserves will be fully depleted (reach zero).

Once past zero, does your rule still work? Explain. What is the range of the data?

If the U.S. continues to go through our coal reserves at this rate, can we consider domestic coal to be a long-

term energy source. Explain your reasoning.

Lesson 1 Activity 2 Handout

Name _____ Date _____ Period ____

Graphing Points and the Carbon Cycle

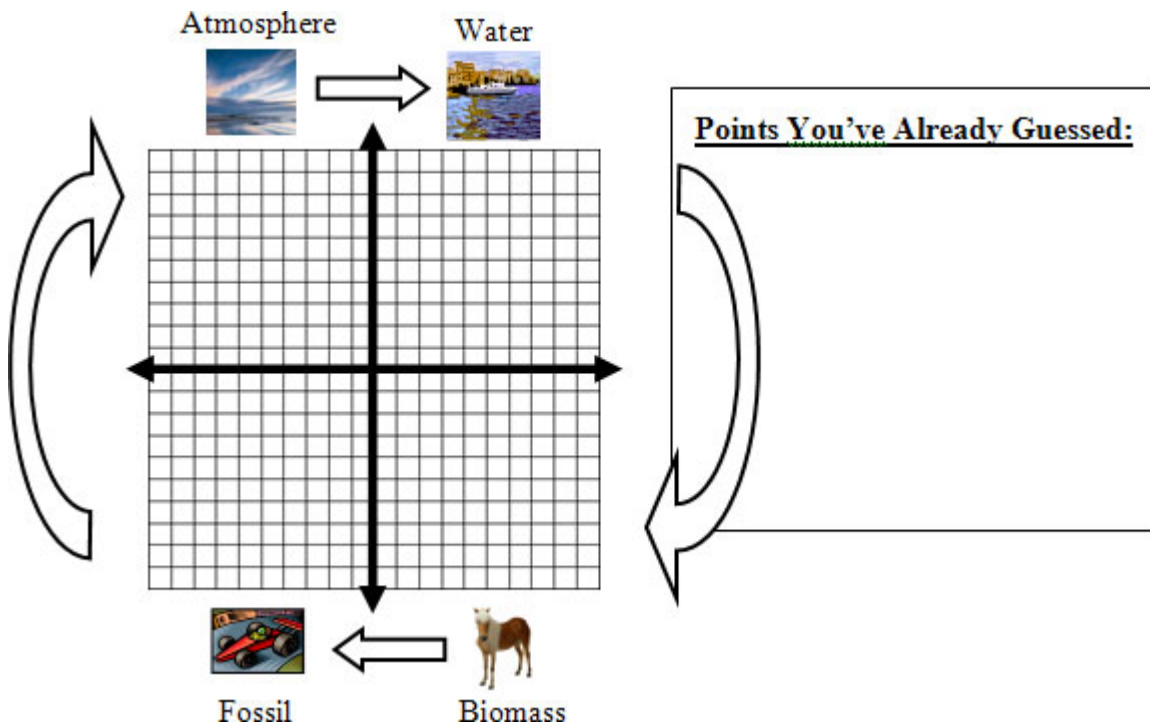
Objective

To practice plotting points and to identify the directions in which carbon moves throughout the carbon cycle.

Directions

To play this game, plot 6 points. Each point you plot represents a carbon molecule in the atmosphere. The game is then played like Battleship: your opponent and you, on alternating turns, attempt to guess where the opposite player plotted his or her points. When the location of a carbon molecule is found, the player that found the molecule will draw a card that indicates where in the carbon cycle the molecule will travel. The first player then hides the molecule at some point in that section of the board. The player that transfers at least 3 molecules to at least 3 different regions wins. Record the points you've already guessed in the box provided. This will help prevent you from repeating your guesses.

The Game Board



Capstone Project Rubric

The provided rubric and grade scale are recommended, but may be adjusted according to the needs of the classroom. This rubric scores students on each of the four sections of the project along with the presentation of their project.

	3	2	1	0
Nonrenewable Energy	The scatter plot is correctly labeled and titled. The points are correctly plotted. A negative correlation is properly identified.	The points are correctly plotted and a negative correlation is identified, but the scatter plot is missing labels.	The points are correctly plotted, but students forgot to label the scatter plot and identify the correlation.	The scatter plot is not labeled properly and the points are plotted incorrectly.
Alternatives	Student research is summarized in a written report. All questions were answered correctly.	Student research is summarized in a written report. Questions are mostly correct.	Student research is summarized in a written report, but the questions are not answered.	Student research is incomplete or inappropriate for the assignment.
Polling the Public	Students properly summarized the purpose of the poll and the results. A scatter plot of the results was properly labeled and plotted. The results were well analyzed.	Students summarized the poll results and properly labeled and plotted a scatter plot. The results were mostly well analyzed.	Students created a scatter plot and analyzed the results with some success.	Students only created a scatter plot, but did not summarize or analyze the results.
Public Service Announcement	The student PSA was creative, edited and included all the required components. Students presented relevant information meant to educate the public about the benefits of renewable energy.	The student PSA was creative and included most of the required components. Additional editing is required, but the PSA is mostly effective as an educational tool.	The student PSA presented relevant information, but requires additional editing. Some of the required components were missing. The purpose was still clear.	The student PSA was poorly edited and was missing many of the required components. The purpose of the PSA was obscure.
Presentation	The presentation was well rehearsed. Students did not rely heavily on note cards to complete their presentation and were able to thoroughly answer questions about their topic.	The presentation was rehearsed, but students depended heavily on note cards when giving their presentation. Questions about the project were well answered.	Students needed to practice their presentation more. Students read their presentation, but could not answer most of the questions about their project.	Students struggled to present their project. They had difficulty replying to questions.

Total Score _____

A 13-15 B 11-12 C 8-10 D 6-7 F 0-5

Implementing District Standards

The described standards are given in the New Haven algebra 1 curriculum for unit 3.

2.1a1 Compare, locate, label and order real numbers on number lines, scales, coordinate grids and measurement tools. (unit addresses graphing points on the coordinate plane in lesson 1).

4.1a1 Collect real data and create meaningful graphical representations of data. (data collection occurs throughout several activities and is then organized as scatter plots to be analyzed in real world contexts).

1.1a1 Identify, describe, and create numeric, statistical patterns, using tables, graphs, in words and symbolic rules. (patterns and correlation are observed and analyzed using data from the Energy Information Agency. Students use tables and graphs to make predictions about future reserve levels).

1.2a1 Represent functions and relations on the coordinate plane. (unit addresses functions in the coordinate plane with all the activities, but is the focus of the first lesson's first activity).

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